SeaWiFS Lunar Image Y-Size Algorithm

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The oversampling correction for the SeaWiFS lunar calibration time series requires a determination of the size of the Moon in the lunar images in the along-track direction, hereafter referred to as the y-size of the Moon. This document describes the current algorithm used to determine the lunar image y-size.

The figure *Band 1 Radiance Profile* shows an along-track radiance profile for the band 1 lunar image for the August 2003 lunar calibration. This is the profile that yields the maximum y-size for the Moon. The profile is shown in blue. The red lines are the edges of the Moon that the y-size algorithm determined for this profile. This profile has the typical double maximum shape for images through the center of the Moon. Profiles that are off center, toward the edge of the image, typically show a single maximum across the image.

To determine the edges of the image, the image is convolved with a Sobel north-gradient kernel to generate the first and second derivatives of the profile. The kernel is:

$$\begin{matrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{matrix}$$

The first derivative of the radiance profile is shown in the figure *Band 1* 1^{st} *Derivative Radiance Profile*. Again, the profile is shown in blue and the edges are shown in red. For this profile through the lunar image, the edges correspond to maxima or minima in the 1st derivative. The maximum and minimum correspond to the two maxima in the original profile. For off-center profiles, the 1st derivative can present problems in determining the two edges of the Moon if there is only a single maximum in the radiance profile.

The second derivative of the radiance profile is shown in the figure *Band 1* 2^{nd} *Derivative Radiance Profile*. Again, the profile is shown in blue and the edges are shown in red. The edge locations are determined by locating the first maximum and first minimum for the profile coming from the off-of-the-Moon direction. The first maximum is the first pixel where the edge of the Moon is detected within the pixel and the first minimum is the first pixel where the Moon fills the pixel completely. The edge location is defined to be the point where the radiance is $\frac{1}{2}$ the difference in the radiances of the pixels at the first maximum and first minimum. The two edges of the profile are determined from the appropriate maximum and minimum. The correspondence of these edges with the maxima and minima for the first

derivative validates the method of edge determination. This method of edge determination also holds for the off-center profiles with a single maximum in the radiance profile.

For each lunar image, the y-size is computed for each profile across the Moon in the along-track direction. The y-size for the image is defined to be the maximum y-size from the various profiles. For this radiance profile, the edges of the Moon are at 38.956 and 59.761 pixels and the y-size of the Moon is 20.805 pixels. For a given lunar calibration, the y-size of the Moon that is used in the oversampling correction is the mean of the y-sizes determined for all eight bands. The standard deviation of this band-to-band mean, over the course of the mission, is 0.18 pixels. This is one estimate of the uncertainty in the determination of the y-size of the Moon.

The y-size of the Moon determined from this algorithm is dependent on the track angle, the angle between the along-track direction and the long axis of the Moon. An off-axis track could interect the lunar terminator rather than the edge of the Moon, yielding an underestimate of the actual size of the Moon in the lunar image. A correction for this underestimation is dependent on both the track angle and on the phase angle of the lunar image (which determines the location of the terminator). The reduction in the image size due to the track angle and the phase angle is:

$$r_{track}(\alpha, \gamma) \;=\; \frac{\cos \alpha}{\sqrt{1 \;-\; (1 \;+\; \cos \alpha)\,(1 \;-\; \cos \alpha)\,(\cos \gamma)^2}} \tag{1}$$

where:

α $\equiv$ phase angle
γ $\equiv$ track angle

The corrected y-size of the Moon is:

$$Y_{Moon}(\alpha, \gamma) \;=\; \frac{2}{r_{track}(\alpha, \gamma) \;+\; 1}\, Y_{obs} \tag{2}$$

where $Y_{obs} \;\equiv$ observed y-size of the Moon.

The angular size of the Moon as seen from the spacecraft is computed in arcseconds, so the y-size of the Moon is converted to arcseconds for use in computing the oversampling correction.